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Whale Stocks

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REPORT ON THE EFFECTS ON WHALE STOCKS OF PELAGIC OPERATIONS IN THE ANTARCTIC DURING THE 1964/65 SEASON AND ON THE PRESENT STATUS OF THOSE STOCKS

by

FAO, Fisheries Division,
Biology Branch

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, 1965

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REPORT ON THE EFFECTS ON WHALE STOCKS OF PELAGIC OPERATIONS IN THE ANTARCTIC DURING THE 1964/65 SEASON AND ON THE PRESENT STATUS OF THOSE STOCKS

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FAO, Fisheries Division, Biology Branch

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, November 1965

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PREPARATION OF THIS PAPER

This paper is essentially an edited version of a report (Doc.IWC/SM/3, and supplement and addendum), submitted by FAO to the Special Meeting of the International Whaling Commission (IWC) held in London in May 1965, and thereafter printed in Norsk Hvalfangst - Tidende (The Norwegian Whaling Gazette), 54 Arg. nr.5, May 1965. It incorporates the supplement and the summary of the report submitted separately to the Special Meeting. This paper contains more complete tables on the catches and catcher days by season, species and division than the original report, both for convenience of the readers and as material for subsequent assessment work. It was made available to the Whaling Committee of the International Council for the Exploration of the Sea meeting in Rome, October 1965. After consultation with the Secretary of the IWC it was decided for convenience to append the short reports (IWC/SM/13 and addenda 1 and 2) prepared by the IWC Committee of four Scientists relating to this paper and which were issued as documents at the Special Meeting of IWC.

Distribution :

FAO Fisheries Division
FAO Regional Fisheries Offices
Regional Fisheries Councils and Commissions
BIWS and Consultants
ICES Whaling Committee
ICES Comparative Fishery Committee
IWC Scientific Committee
IUCN and related organizations
ACMRR
FBCB Selector 5

"Current Bibliography" entry :

FAO. Fisheries Division, Biology Branch (1965)
FAO Fish.tech.Pap., (59):36 p.
Report on the effects on whale stocks of pelagic operations in the Antarctic during the 1964/65 season and on the present status of those stocks.

Report submitted by FAO to IWC. Contains tables on the catches and catcher days by seasons and spp. Incl. tables of data for subsequent assessment work. Appends a short report by the IWC Committee of 4 Scientists.

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REPORT ON THE EFFECTS ON WHALE STOCKS OF PELAGIC OPERATIONS IN THE ANTARCTIC DURING THE 1964/65 SEASON AND ON THE PRESENT STATUS OF THOSE STOCKS

Summary

The findings are reported of a Working Group consisting of L.K. Boerema, J.A. Gulland and S.J. Holt, which met in Rome from 5th to 8th April 1965. An analysis was made of provisional data for the Antarctic catch of baleen whales in the 1964/65 season, kindly made available by the Bureau of International Whaling Statistics under an agreement between the Bureau and FAO.

The whaling effort was about 13% less than in the previous season, and the total catch in BWU's was about 17% less. Only 19 blue whales were caught. The catch per catcher day for fin-whales declined more than had been predicted and that of sei-whales increased as a consequence of an important change in the distribution of effort by the expeditions to areas in which sei-whales are most abundant and also by their tending to give more attention to that species generally. When allowance was made for this change the 1964/65 data supported the assessments made in past years by the Special Committee of Four Scientists of the International Whaling Commission.

The sustainable yield of fin-whales is now about 4,000 whales. As a result of the fact that sei-whales in 1964/65 were a sought, rather than an incidental,species, it was possible to obtain an estimate of their numbers as at the beginning and at the end of the season. The large 1964/65 catch probably reduced the initial stock of about 60,000 by about one-third, and the present level is of the order of one half of the unexploited level. The sustainable yield at the present stock level is probably about 3,000-3,500 whales and this stock level is also probably near to that which would give the maximum sustainable yield.

The group then examined the consequences of some rational exploitation policies such as would conserve the fin-whale stock, permitting it to begin to recover, and at the same time maintain the sei-whale stock at something like its present level. If the total catch in 1965/66 were kept to not more than 2,500 BWU, consisting of not more than 4,000 fin and 3,000 sei whales the stock of neither species would be further reduced.

One policy of the type proposed during the 16th Meeting of the IWC - namely a series of diminishing quotas in three successive years, the quota of the first year being higher but that of the third year lower than the sustainable yield in that year, and thereafter being maintained at the level of the third year, or below - could, if applied as from the 1965/66 season, still be regarded as a conservation policy, although to be sure that the stocks were not further reduced the series of quotas would have to be somewhat lower than the values of 4,000, 3,000 and 2,000 BWU proposed at the 16th Meeting. The consequences of applying such a policy now would not, however, be so beneficial as they would have been if the policy had been applied in 1964/65. This is because the recruitment of fin-whales is now less, and also because the sei-whale stock was drastically reduced by the large 1964/65 catches. This latter factor means that the opportunity to

permit the fin-whale stock to begin to recover, yet at the same time to sustain the industry while it is rationalizing itself at a lower level of operation, by easily taking a rather large sei-whale catch, has now been substantially lost. It should still be possible, however, to put into effect a conservation policy which would nevertheless permit continuation of pelagic whaling.

1. Introduction

At the close of the 16th Meeting of the International Whaling Commission in June 1964 no arrangements had been finalized for continuing assessment of the Antarctic whale stocks, following the completion of the assignment of the Commission's Special Committee of Three (later Four) Scientists. The Commission had proposed that FAO might undertake this work in co-operation with the Commission's Scientific Committee, and FAO had agreed to this proposal in principle. At the same time, however, in view of the failure by the Commission at its 1964 meeting to achieve agreement on measures to be taken to bring the whaling regulations into line with the scientific findings (in accordance with its declared intention in 1960, at the time of establishing the Committee of Three), FAO expressed the wish not to be associated with a policy which could imply, ultimately, the effective destruction of the whale resources.

There was nevertheless clearly an urgent need for an appraisal of the consequences of continued intensive pelagic whaling in the hope that at some future date it would prove possible for the interested countries to agree on measures of conservation and rational exploitation of the whale stocks. Accordingly FAO, by an exchange of letters in September 1964, arranged to co-operate with the Bureau of International Whaling Statistics in appraising the statistical data for the 1964/65 and following seasons. The BIWS thus kindly agreed to make available advance data for this purpose.

Meanwhile, it had been decided to convene, early in May 1965, a special meeting of the Commission for the express purpose of enabling delegations "to reconsider the Antarctic catch position in relation to the scientific evidence" (Secretary's circular letter of 4 February 1965). FAO therefore arranged for a group of scientists specialized in marine stock assessment to make a special analysis of data kindly provided by the BIWS. This group consisted of Mr. J.A. Gulland (U.K., former member of the Committee of Four), Mr. S.J. Holt (FAO, also formerly a member of the Committee of Four) and Mr. L.K. Boerema (a Dutch scientist who had recently joined the FAO staff as Stock Assessment Specialist in the Biology Branch of Fisheries Division). The group met in Rome from 5 to 8 April 1965 and prepared their report on the basis of data available to the BIWS on 1 April, and covering details of catches and whaling effort up to the end of February 1965, and the catches by countries, in Blue Whale Units (BWU), until the end of March, almost the close of the season. The present report is the revised version prepared when the figures for the whole season became available. This revision necessitated only minor amendments and no changes of substance have been made.

The group did not attempt any re-appraisal of data for the previous seasons, but only brought up-to-date the analyses and conclusions presented to the Commission by its Committee of Four in 1964 (International Commission on Whaling. Fifteenth Report of the Commission, London 1965,pp47-60, and see also pp 61-63).

The report of the group was transmitted to the IWC for consideration at its special session, and also to other interested bodies and persons, and specifically to the I.U.C.N., the Fauna Preservation Society and to the former members of the Committee of Four, who had all asked to be kept informed of the results of this work.

2. Analysis of the 1964/65 catches

The total pelagic catch in the 1964/65 season amounted to 6980 BWU.

Table 2. Annual catches of fin and sei whales

Species	Fin	Sei	Ratio : Sei/Fin
Season			
1960/1	27,299	4,280	0.16
1961/2	26,364	4,716	0.18
1962/3	18,636	5,482	0.29
1963/4	13,853	8,256	0.60
1964/5	7,305	19,845	2.72

The very great increase in both the absolute and relative numbers of sei whales in the 1964/65 catch is an acceleration of a trend which began a few years ago. Though a relative increase in sei whales is to be expected as the fin whale stock declines, it is most unlikely that there has been any considerable increase in the absolute abundance of sei whales, - certainly not to the extent that the catches have increased. The increased catches are surely due to increased attention being paid to sei whales, both by a bigger proportion of sei whales which are sighted being pursued and caught, and also by the expeditions concentrating more in areas where sei whales are abundant. (This change in practice may be due both to the decline in fin whales and to the greater attractiveness of the sei whale, with its relatively greater meat content, at a time when whale meat and other products, especially meat extract, contribute an increasing part of the value of the catch).

The change in geographical distribution is shown in Tables 3 and 4 overleaf, which give the percentage distribution of the total catcher days in each of the past three seasons by Areas and Series (latitudinal zones). Because there was a marked change within Area II, this has been divided for the purpose of this analysis into Sub-Area II W (30-60°W) and Sub-Area II E (0-30°W). There were no such marked changes in the other areas, which therefore did not call for sub-division.

These tables show that in the 1964/5 season whaling increased very much in the western part of Area II, and decreased in Area III, and that there has been a continued shift northwards from Series B and C into Series D. In the appendix tables the details of effort and catches per unit effort of fin and sei whales are given, and they show that the statistical divisions, especially the north-western part of Area II, where whaling has increased, are those where sei whales are most abundant; that is, the change in distribution has been in the direction to be expected if there were a greater emphasis on catching sei whales.

Table 3. Percentage distribution of catcher days in each season by area

Season	Sub-Area II W 30-60°W	Sub-Area II E 0-30°W	Area III 0-70°E	Area IV 70-130°E	Area V 130°E-170°W	Area VI 170° - 120°W	Area I 120° - 60°W	All Areas
1962/3	13.1	14.0	41.7	12.4	5.6	2.7	10.5	100
1963/4	12.4	28.8	32.5	9.6	16.2	-	0.5	100
1964/5	41.7	18.0	9.8	13.0	17.0	-	0.5	100

Table 4. Percentage distribution of catcher days by series

Series / Season	D 40-50°S	A 50-60°S	B 60-70°S	C 70-80°S	All Series
1962/3	22.3	45.3	32.3	0.1	100
1963/4	22.7	62.4	14.9	-	100
1964/5	38.3	52.2	9.5	-	100

The total catch of blue whales was only 19 individuals, all taken by USSR expeditions in February and March. The group at the time of preparing the original report did not have data available for the Antarctic catches of sperm whales, so no account could be taken of possible changes in these which could have some influence on interpretations of changes in the catches per catcher days work of the baleen species. It was subsequently reported that the catches of sperm whales by all expeditions except one amounted to 7949 in 64/65 as compared with a total catch of 10261 in 1963/64.

Catches per unit effort

Catch and effort data for the season 1964/65 and the corresponding figures for 1963/4 are given in Table 5.

Table 5. Catches and effort in 1963/4 and 1964/5

Season	Effort (catcher days)	Catch			Catch per catcher day		
		Fin	Sei	BWU*	Fin	Sei	BWU*
1963/4	20,407	13,853	8,256	8,448	0,68	0,40	0,41
1964/5	17,521	7,305	19,845	6,980	0,42	1,13	0,40

* including blue whales

This table shows that there has been a decline in the number of catcher days work by about 14%, which is greater than can be accounted for by the withdrawal of one expedition. In fact, both the USSR and Japan, though operating the same number of expeditions, used fewer catchers. As the catchers withdrawn are likely to have been the less efficient ones, the average efficiency of the catchers may have increased by more than the very small increase in average tonnage (from 709 to 715 gross tons, i.e. about 1%).

No detailed corrections can be made for the effect of weather, but it is known that the Norwegian expeditions, at least, enjoyed good weather, and for this reason their effective effort should have been high.

The catch per catcher days work in BWU shows virtually no change, although a slight decrease might become apparent if allowance were made for any increase in the average efficiency of the catchers, as well as the slight increase in their average size. From the report of the Committee of Four, the catch of fin whales, by the same effort as in 1963/4, was expected to decline from 14 to 12 thousand, i.e. by 14%, whereas in fact the catch per unit effort declined by 38%. On the other hand, although it is unlikely that the stock of sei whales increased, the catch per unit effort of that species increased nearly three fold.

This discrepancy between the observed and expected changes in catch per catcher day is presumably due to the increased concentration of effort on sei whales. To examine this problem, the catch per catcher day was calculated by Areas and Series (see Appendix). There are large difference between divisions (group of statistical squares within each area and series) particularly for sei whales, and these differences are reasonably consistent from season to season; thus the catch per effort of sei whales generally increases from south to north, and is greatest in the western part of Area II. The best measure of the abundance of the stocks is obtained as the average of the catch per unit effort in each division. Because catching did not occur in every division in each year, an improved estimate of the change in stock between 1963/4 and 1965/5 is obtained by averaging the catch per catcher day in those divisions in which catching occurred in both seasons (marked in the Appendix tables).

Table 6 compares the indices of stock abundance for 1963/4 and for 1964/5, as estimated first by the ratio of total catch to total effort, and secondly by the average of the catch per effort in each division.

Table 6. Indices of stock abundance of fin and sei whales

	Total catch / Total effort		Average catch per unit effort	
	Fin	Sei	Fin	Sei
1963/4	0.68	0.40	0.62	0.36
1964/5	0.42	1.13	0.43	0.72
Ratio 1964/5:1963/4	0.62	2.8	0.69	2.0

The improved estimates still show a bigger decrease for fin whales than expected, and an increase for sei whales, but the change in average catch per catcher day by division is closer to the expected change in stock than is the change in the ratio of total catch:total effort. The divisions used are very large and clearly it is very probable that some redistribution of effort within divisions also occurred, as well as a greater tendency to chase and catch any sei whales seen. If these factors were also taken into account, it is likely that the discrepancy between the observed and expected changes of catch per unit effort of both sei and fin whales could be fully accounted for.

Fin whales

In the report of the Committee of Four (IWC 16/10), it was predicted that, with the same effort as in 1963/4, the 1964/5 catch would be 12,000. On the basis of the Committee of Four calculations, had it been known what whaling effort would be exerted in 1964/65, the fin whale catch would have been predicted as about 10,500. The actual pelagic catch - 7,305 - was thus much less than expected, even allowing for the reduced number of catcher

days. This discrepancy can satisfactorily be accounted for by the arguments given on page 6. The change in distribution of the whaling operations means, however, that the data from the 1964/5 season do not provide much additional information on the state of the fin whales stocks other than confirming that these stocks are now greatly depleted, and also that they continue to be over-exploited as the catch was much more than the sustainable yield of the present stock.

The estimated stock at the beginning of the 1964/5 season was 35,000-36,000 (IWC 16/10, p.2), so that taking into account the catch of around 7,800 fin whales taken in the whole Antarctic season (pelagic plus South Georgia), the estimate of the stock at the beginning of the 1965/6 season is 34,000-35,000 whales. (The decrease in the stock is less than the excess in catch over the sustainable yield of 4,000 whales which can be taken from a steady stock of 34,000/35,000 whales, because the stock is benefitting from the recruitment from the rather higher parent stock of 1960).

The sustainable yield from a steady stock of this size is about 4,000 fin whales. It should, however, be emphasized that the continued taking of catches of this magnitude will not permit the stock to increase at all (apart from the temporary benefit of a very few thousand whales recruiting from the larger parent stock of earlier years). If the stock is to be permitted to increase so as to provide higher sustainable yields in the future, the catches in the immediate future must be less than the present sustainable yield.

Sei Whales

Until the 1963/4 season, it was not possible to use the catches per unit effort of sei whales to give estimates of stock abundance because the catchers were not concentrating mainly on that species; in fact interpretation of these data presented much the same difficulty as was met in earlier years in relation to fin whales when blue whales were still sufficiently abundant to be the species mainly sought. In 1964/5, however, in certain statistical squares, especially those in the western part of the South Atlantic where the greatest amount of catching was done, sei whales made up the greater part of the catch (up to 95% by numbers), and the expeditions concerned were certainly concentrating mainly on sei whales. Outside the predominantly sei whale areas the expeditions may have been concentrating more on fin whales than on sei whales, but presumably catchers would now not ignore any sei whales seen. This new feature of concentration on sei whales, while, as noted above, introducing a difficulty into the interpretation of data for the fin whale catches per unit effort, creates a situation in which better estimates of sei whale stock size can be obtained. If sei whales are not much more or less easy to detect, and, once detected, to catch and kill, as are fin whales, then the relation of catch per unit effort to stock abundance will be the same for both species. In the season the average catches per catcher day of fin whales and sei whales were 0.42 and 1.13 respectively (see Table 6, columns 1 and 2). The average stock of fin whales in this period was:

34,000 - 3,900 (half the catch during the period) = 30,100

Therefore an estimate of the average stock of sei whales during the same period is:

$$30{,}100 \times \frac{1.13}{0.42} = 81{,}000$$

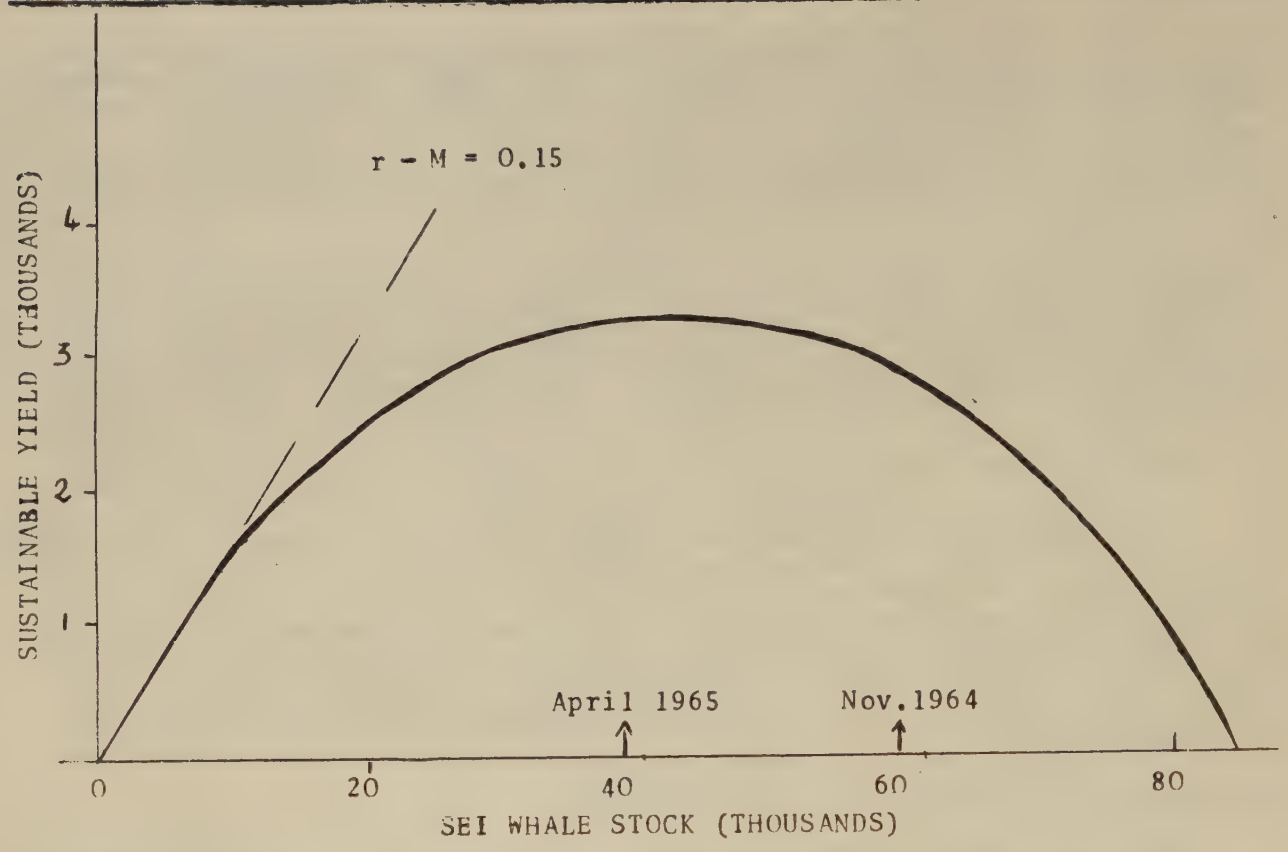

Figure 1. Likely stock/sustainable yield diagram for Antarctic Sei Whale

Assuming the simple logistic model for population growth, the relation of sustainable yield, Y, to stock N, would be a parabola described by

$$Y = a\,(2N.N_{opt} - N^2)$$

where N_{opt} is the stock size which gives the maximum sustainable yield, Y_{max}.

For this model it can easily be shown that

$$Y_{max} = a\,N^2_{opt} \quad \text{and} \quad \frac{dY}{dN}_{N\to o} = 2a\,N_{opt}$$

so that

$$Y_{max} = \left(\frac{dY}{dN}\right)_{N\to o} \times \frac{N_{opt}}{2}$$

In this case

$$N_{opt} = \frac{N_{max}}{2} = \frac{85,000}{2} = 42,500$$

$$\left(\frac{dY}{dN}\right)_{N\to o} \simeq (r - M) = 0.15$$

so that

$$Y_{max} = 42,500 \times \frac{0.15}{2} = \text{about } 3,200$$

However, the catch per unit effort of sei whales was high because catching was concentrated in the areas where sei were more abundant. A better measure of abundance is probably therefore that based on the average catch per unit in each division (Table 6, columns 3 and 4). The corresponding estimate of the stock of sei whales is then

$$30,100 \times \frac{0.72}{0.43} = 50,400$$

Even this estimate does not involve due allowance for any concentration of effort within divisions. On the other hand, it is possible that some gunners may still pursue sei whales less intensively than fin whales. These two factors would affect the estimates in opposite directions, so that about 50,000 may be taken as the best estimate at present available. Adding to this figure half the catch during the period gives an estimate of the stock at the beginning of the 1964/5 season as 60,000 sei whales. In this connection it should be noted that the Committee of Four (IWC 16/10, p.2) gave probable limits of the stock of sei whales, based on rather different arguments and with fewer data, as between 20,000 and 70,000. This latest estimate, it must be emphasized, cannot be considered to have the same order of accuracy as the estimates of fin whale stock; nevertheless, the group considered it to be sufficiently reliable to justify an attempt to ascertain the sustainable yield of the sei whale stock and to take account of its dynamics in considering the consequences of alternative regulation policies. In this connection it will be recalled that the members of the Committee of Four were in a position to consider the reaction only of the fin whale stock in their estimate of the possible benefits of three different proposals before the Commission at its 1964 meeting (IWC 16/20).

Sustainable yield of sei whales

Although no direct estimates of the present, or of the maximum, sustainable yields of sei whales can yet be made some useful indirect estimates can be obtained by analogy with the blue and fin whale stocks.

Before the 1957/8 season, catches of sei whales were negligible. Between then and the beginning of the 1964/5 season the total cumulative catch was just under 30,000 sei whales. A reasonable estimate of the sei whale population at its maximum in the winter of 1957 is therefore :

$$60,000 + 30,000 - \begin{pmatrix}\text{allowance for net recruitment during} \\ \text{the seven years, say } 5,000\end{pmatrix} \simeq 85,000 \text{ whales.}$$

Using this value a Schaefer diagram of sustainable yield against population size can be drawn, corresponding to those given for fin and blue whales in the Committee of Three report (IWC 14th Annual Report, Figures 3,4,5 and 6). Assuming a symmetrical curve, and taking an optimistic value of the net recruitment rate at low population levels as r - M = 0.15 (the values used in the figures referred to above were 0.1 for blue whale and 0.12 for fin whale), the curve of Figure 1 is obtained.

Clearly, conclusions drawn from this figure will be much less reliable than those made for fin and blue whales, but the group believed that it does provide a useful guide to the present state of the sei whale stocks, and the likely sustainable yields. In any case, it would be sounder, in the light of the information now available, to follow such a guide than to continue to proceed on the assumption that whaling has not had

a substantial effect on the sei whale stock and that therefore in future years the catch per unit effort of sei whales will not decline. Corroborative evidence that whaling has, on the contrary, in fact been having an important effect on the stock, is the steady decline of the mean lengths of sei whales in catches of the past five seasons.

On Figure 1 the probable stock sizes at the beginning and end of the 1964/5 season are shown. It appears that before the season, the abundance of sei whales was greater than that giving the maximum sustainable yield, but that by the end of the season the stock had been reduced to about, or a little below, the level giving the maximum sustainable yield. The maximum yield is quite small; surely not more than 4,000 whales, more likely of the order of 3,000 whales, possibly even considerably less than this, and in any case much less than the 1964/5 catch. Indeed it is likely that another two seasons with catches of the same magnitude as in 1964/5 - even bearing in mind that recruitment might stay quite high for 2 or 3 years - would reduce the stock to negligible proportions. That is, the exploitation of sei whales appears to be following the same unhappy trend as did that of blue and then fin whales, though at a greatly increased rate. The rate of depletion is faster because the pelagic whaling effort - even though reduced somewhat in the last season - is now much greater in total than it was at the times of most rapid depletion of the other species, and furthermore is concentrated with great intensity on the relative smaller areas of abundance of the sei whale.

Further examination of the effects of different quotas

In this section of the report, the term "sustainable yield" from a stock of a given number of whales means the yield that could be taken, year after year, from a stock of legal sized whales of that number, leaving the numbers in the stock unchanged. The sustainable yield of fin whales at the present order of stock size has, following the procedure adopted by the Committee of Four, been calculated as 0.12 x the stock at the beginning of the season concerned. This value may have to be revised as further data become available, but it is most unlikely that such revision will alter the estimates of the sustainable yields by more than a few hundred whales in either direction. If at any time the stock has been recently reduced, then the total stock of whales of all sizes will include an exceptionally large proportion of undersized whales, which will recruit to the fishable stock in the next three or four years, because these small whales are the offspring of the larger numbers of mature whales in earlier years. If a catch, equal to the sustainable yield, is taken from such a stock, then the total stock of whales will be unchanged, but there will be proportionally fewer small whales, and the stock of whales of legal size will actually increase. This fact should be kept in mind in view of some apparent inconsistencies between the excess of catch over sustainable yield, and the change in stock. Thus the catch of fin whales in the 1964/65 season was some 3,000 in excess of the sustainable yield, but the stock of legal sized whales was estimated to have decreased by only about 1,000 whales; however, the number of young, undersized whales decreased by about 2,000.

Here an attempt is made briefly to appraise certain alternative policies of regulation of Antarctic pelagic whaling. The alternative policies which could theoretically be considered are, of course, innumerable, and at the time of writing there were no specific proposals before the IWC or any other international body. The only policies which

can be considered as meeting the objective of recovery and eventual rational exploitation of the resources are those which lead within a specified time to catches of each species not exceeding sustainable yields and to stocks increasing towards levels at least as high as those giving maximum sustainable yields. In this situation it seemed useful to re-examine those policies which were considered by the IWC at its 1964 meeting and which offered some measure of restraint and conservation.

Firstly, it may be said that the only policy which would imply an immediate step towards conservation in the 1965/66 season is one that would ensure that :

a) the fin whale catch did not exceed the present sustainable yield of about 4,000 whales = 2,000 BWU,

b) the sei whale catch did not exceed its present sustainable yield, and

c) capture of blue whales was prohibited

With respect to element b) there will be, in the coming year, a recruitment which is greater than the present stock will produce, as it is coming from the larger stock of earlier years. Now that the sei whale stock has been rather drastically reduced, the recruitment of future years will be correspondingly reduced. Thus the catch of sei whales in 1965/66 which will leave the stock of legal sized whales virtually unchanged, is something rather more than the value of about 3,000-4,000 (=500-650 BWU), which is estimated as the sustainable yield in the steady state condition of a stock of the present size (which is, it seems, near the optimum level); how much more could only be determined by a detailed analysis of all available data for sei whale as recommended by the Committee of Four.

We can say then that only if the total catch in 1965/66 were less than 2,500 BWU, would it be ensured that both fin and sei whale stocks were not further depleted. (If it were in fact possible to take, say, 6,000 sei whales in 1965/66 - but only in that season - without further depletion of that stock, then the corresponding value of total catch would become 3,000 BWU).

It is important to remember that this result would only be achieved if the total BWU were composed of fin and sei whales in the ratio of about 1:1.

At this point something more must be said about the fin/sei ratio. For the predictions made at the Commission's 1964 meeting of the consequences of various alternative policies, a range of assumptions had to be made as to the way and extent to which this ratio would change in favour of sei whales; the situations considered were the ratios 1:1 and 2:1, compared with an actual ratio in the 1963/64 catches of 1.7:1. In fact, as we have seen the ratio in 1964/65 moved even more in favour of sei, to about 1:2.7. This ratio of fin/sei in the catches has been, up to now, changing in favour of sei for two reasons: because the fin whale stock has been decreasing faster than the sei whale stock, and because increasing attention has been paid to sei whales. In the past season the sei whale stock almost certainly decreased proportionately much more than the fin whale stock. Also, whaling was concentrated quite intensively on the sei whales (or at least in areas where sei whales were most abundant), and with the decreasing sei whale stock, the relative concentration on sei whales may

decrease. For both these reasons the fin/sei ratio in the catches may be expected to change again. To maintain it would require a further redistribution of whaling effort towards sei whales to a greater degree than appears possible. The group expects, therefore, that if catchers are left in the 1965/66 season to choose freely fin or sei whales, the ratio will return to a value of between 1:1 and 1:2. The actual expected value will depend on whether or not a BWU limit is set for the forthcoming season. If one is set, and at such a level that the expeditions can achieve their parts of the national quotas before the end of the season (that is, if the quota is in fact a restraining one)*, then since the BWU favours the sei whale the ratio is likely to be nearer 1:2. Without restraint, the ratio is likely to approach 1:1 as the sei whale stock stabilizes or is further reduced.

The effort required to obtain the 2,500 BWU constituted by the sustainable yields of fin and sei whales cannot be estimated precisely, but it is certainly rather less than half the 1964/65 effort.

Before considering alternative policies, we may examine the consequences of unlimited pelagic whaling in the 1965/66 season. The predictions depend, of course, on the whaling effort which it is assumed would, in fact, be exerted, and also on the relative concentration of that effort on fin or sei whales.

First, we assume that the total effort in 1965/66 will be effectively the same as in 1964/65, and that the distribution of effort is also the same. The catch of fin whales in 1964/65 was such that the stock present at the beginning of the 1965/66 season will be about 5% less than at the beginning of the 1964/65 season, so that the expected pelagic catch of fin whales in 1964/66 would be about 95% of 7,300, i.e. 7,000. The 1964/65 sei whale catch reduced the stock by about one-third, and, making some allowance for the still rather high recruitment expected for the next one or two years, the expected catch of sei whales would be somewhat more than two-thirds of the 1964/65 catch of about 20,000, i.e. of the order of 15,000, giving a fin sei total of 6,000 BWU.

If the total effort in 1965/66 is less than in 1964/65, but its distribution more or less the same, these estimates will be reduced proportionately. If the distribution of effort reverts towards rather greater concentration on fin whales, as a result of the reduction in abundance of sei, then the fin whale catch could be rather more than 7,000 (but not more than 95% of 10,500 $\simeq$ 10,000) and the sei whale catch correspondingly less than the above values.

The group then considered a specific proposal (policy A in document IWC/16/20) aimed at ensuring that by the third year less than the sustainable yield would be taken. This policy involves the setting of a progressive series of total quotas: 4,000 BWU in the first season, 3,000 in the second, 2,000 in the third and thereafter catches of less than or equal to the sustainable yield of each species. The relevant table of document IWC/16/20 has been re-calculated, firstly to take account of the slightly smaller stock of fin whales which will be present at the start of the 1965/66 season, and also to cover patterns of catches with a greater proportion of sei whales than the ratios of 1 fin : 1 sei and 2 fin : 1 sei used last year. These calculations are given in Table 7.

* Whether or not the subsequently agreed overall quota of 4500 BWU meets this criterion depends on the actual number of expeditions sent to the antarctic in 1965/66.

Table 7. Recalculations of the consequences of Policy A of Document IWC/16/20, if applied as from 1965/66, and with revised fin : sei ratios

Ratio Fin:Sei		1:1		1:2		1:3	
Season	Quota (BWU)	Catch Fin	Sei	Catch Fin	Sei	Catch Fin	Sei
1965/66	4,000	6,000	6,000	4,800	9,600	4,000	12,000
1966/67	3,000	4,500	4,500	3,600	7,200	3,000	9,000
1967/68	2,000	3,000	3,000	2,400	4,800	2,000	6,000
At opening of 1968/69	Stock	32,900		35,300		36,900	
	sustainable yield	3,900		4,200		4,400	

For fin whales the conclusions are substantially the same, except that the stock and sustainable yield in the fourth year (1968/9) are rather less than had been predicted last year for the 1:1 fin/sei ratio due to the slightly smaller initial stock and the declining recruitment; for the 1:2 fin/sei ratio the fourth year stock is about the same; for the 1:3 ratio it is rather larger. The important fact is that in the third year less than the sustainable yield would be taken, and the stock would be allowed to recover slowly.

For sei whales, it was concluded in document IWC/16/20 that this policy would leave the stock not much changed, and possibly permit it to increase under a regime of 2,000 BWU annually after the third year. However, this was stated before the stock had been greatly reduced by the very large 1964/65 catches, and took into account annual catches of at most 6,000 sei whales, decreasing to 3,000 in the third year. With the present reduced stock the large sei catches implied by the 1:3 ratio - and possibly also by the 1:2 ratio - would further reduce the stock, possibly by the third year to a level at which the stated catches could not be taken, or could only be taken with a greatly increased effort. Certainly, if the proportion of sei whales were allowed to remain around the high value of 1964/65, policy A would not lead to less than the sustainable yield of sei whales being taken, even in the third year.

The effort required to reach the quotas implied by policy A has not been calculated, since there would again be some redistribution between fin and sei whales, but qualitatively the conclusion - at least so far as the effort required to reach the fin quota is concerned - would be the same ; almost half of the 1964/65 effort would be required in 1965/66, and progressively less in each following year.

This policy could be modified to ensure that less than the sustainable yield of sei whales as well as of fin whales is taken by the third year, perhaps by setting a series of smaller BWU quotas, and/or by restricting the catch of sei whales by other means. Another possibility to consider would be to permit the deliberate over-exploitation of the less important sei whale for a limited period, during which the catching of fin whales would be greatly restricted to permit a more rapid recovery of the stock of that species. During this period the industry would need to be rationalized at the necessary lower level.

The best time to have put a policy of the latter kind into effect would, however, have been the 1964/65 season, or earlier, when the stock of sei whales was still large (probably above the optimum level giving the maximum sustainable yield) - in fact large enough to provide the greater part of the catches of a dozen expeditions.

Finally, it should be reiterated that, as stated by the Committee of Four, the only rational policies are those that provide, in one way or another, for limitation of the catches of each species separately, rather than - or as well as - the limitation by BWU. In the present situation this might be achieved by an appropriate adjustment of open seasons for fin whales or sei whales or both.

Footnote

At its 17th Meeting in London, June 1965, the IWC adopted a recommendation that the total quota for the 1965-66 Antarctic season should be 4,500 BWU. The predicted effects are given in the APPENDIX II, Table 1a. The effort required to obtain this catch will probably be about :

$$\frac{4500}{6000} \times 17{,}520 \simeq 12{,}000 \text{ catcher days}$$

APPENDIX I

In the original report these tables covered only the 3 seasons 1962/3 to 1964/65, and the last only partially. The tables here have been completed and extended back to 1959/60 for convenient reference.

Total number of catcher days (uncorrected)
by season and division

Season	Area / Series	II W	II E	III	IV	V	VI	I	Total
1959/60	D a/	-	-	-	-	-	-	-	-
	A a/	820	2293	36 64	3633	567	-	-	10977
	B	982	607	3681	526	3302	459	446	10003
	C	-	-	-	-	34	183	72	289
.....	Total	1802	2900	7345	4159	3903	642	518	21269
1960/61	D	-	-	1464	207	-	-	-	1671
	A	706	2429	6394	1171	784	564	-	12048
	B	944	864	2779	36	2280	2650	504	10057
		-	-	-	-	-	222	-	222
.....	Total	1650	3293	10637	1414	3064	3436	504	23998
1961/62	D	391	31	1134	245	-	-	-	1801
	A	1189	5305	7947	2338	-	-	500	17279
	B	526	810	2317	566	1780	1799	2886	10684
	C	-	44	-	-	-	108	36	188
.....	Total	2106	6190	11398	3149	1780	1907	3422	29952
1962/63	D	220	183	4209	396	-	-	-	5008
	A	1289	2784	4678	990	-	19	425	10185
	B	1447	173	497	1400	1228	597	1935	7277
	C	-	-	-	-	34	-	-	34
.....	Total	2956	3140	9384	2786	1262	616	2360	22504
1963/64	D	544	127	2692	383	875	-	-	4621
	A	1897	5637	3537	727	923	-	22	12743
	B	86	132	408	840	1505	-	72	3043
.....	Total	2527	5896	6637	1950	3303	-	94	20407
1964/65	D	3194	823	675	1611	404	-	10	6717
	A	4101	2338	914	344	1378	-	64	9139
	B	8	-	147	324	1186	-	-	1665
.....	Total	7303	3161	1736	2279	2968	-	74	17521

a/ Data referring to "D" are included with "A".

Catches of FIN whales by season and division

Season	Area / Series	II W	II E	III	IV	V	VI	I	TOTAL
1959/60	D a/	-	-	-	-	-	-	-	-
	A a/	1063	2471	5852	5928	801	-	-	16115
	B	1021	365	3455	573	3887	303	410	10014
	C	-	-	-	-	42	98	2	142
.....	Total	2084	2836	9307	6501	4730	401	412	26271
1960/61	D	-	-	1182	259	-	-	-	1441
	A	732	2950	8868	1810	790	374	-	15724
	B	872	669	3219	17	2384	2417	373	9951
	C	-	-	-	-	-	183	-	183
.....	Total	1604	3619	13269	2086	3174	3174	373	27299
1961/62	D	123	-	971	69	-	-	-	1163
	A	1043	4823	8830	2726	-	-	155	17577
	B	197	436	2046	334	1098	1109	2361	7581
	C	-	28	-	-	-	11	14	43
.....	Total	1363	5287	11847	3129	1098	1120	2520	26364
1962/63	D	21	284	3341	101	-	-	-	3747
	A	957	3106	5328	785	-	5	221	10402
	B	1182	20	308	839	633	341	1152	4475
	C	-	-	-	-	12	-	-	12
.....	Total	2160	3410	8977	1725	645	346	1373	18636
1963/64	D	587	147	1084	35	248	-	-	2101
	A	1281	5205	3426	279	347	-	24	10562
	B	11	88	243	289	549	-	10	1190
.....	Total	1879	5440	4753	603	1144	-	34	13853
1964/65	D	896	451	373	504	44	-	22	2290
	A	1860	1321	776	148	457	-	44	4606
	B	-	-	50	113	246	-	-	409
.....	Total	2756	1772	1199	765	747	-	66	7305

a/ Data referring to "D" are included with "A".

Catches of SEI whales by season and division

Season	Area / Series	II W	II E	III	IV	V	VI	I	TOTAL
1959/60	D a)	-	-	-	-	-	-	-	
	A a)	123	28	40	333	231	-	-	755
	B	272	-	190	193	1401	213	159	2428
	C	-	-	-	-	17	19	-	36
.....	Total	395	28	230	526	1649	232	159	3219
1960/61	D	-	-	75	28	-	-	-	103
	A	280	113	147	72	269	495	-	1376
	B	699	54	114	3	294	1518	102	2784
	C	-	-	-	-	-	17	-	17
.....	Total	979	167	336	103	563	2030	102	4280
1961/62	D	278	-	165	76	-	-	-	519
	A	354	222	218	538	-	-	213	1545
	B	376	19	44	19	409	345	1408	2620
	C	-	-	-	-	-	24	8	32
.....	Total	1008	241	427	633	409	369	1629	4716
1962/63	D	122	11	1215	176	-	-	-	1524
	A	503	214	242	124	-	1	185	1269
	B	958	4	-	331	430	344	622	2689
	C	-	-	-	-	-	-	-	-
.....	Total	1583	229	1457	631	430	345	807	5482
1963/64	D	413	32	1286	174	393	-	-	2298
	A	1182	2495	683	34	474	-	1	4869
	B	28	-	15	66	953	-	27	1089
.....	Total	1623	2527	1984	274	1820	-	28	8256
1964/65	D	6949	183	337	1368	512	-	5	9354
	A	6741	1708	109	138	903	-	35	9634
	B	-	-	7	58	792	-	-	857
.....	Total	13690	1891	453	1564	2207	-	40	19845

a/ Data referring to "D" are included with "A".

Percentage distribution of uncorrected catcher days by season and division

Season	Area / Series	II W	II E	III	IV	V	VI	I	TOTAL
1959/60	D a/	-	-	-	-	-	-	-	-
	A a/	3.9	10.8	17.2	17.1	2.7	-	-	51.7
	B	4.6	2.8	17.3	2.5	15.5	2.1	2.1	46.9
	C	-	-	-	-	0.2	0.9	0.3	1.4
.....	Total	8.5	13.6	34.5	19.6	18.4	3.0	2.4	100.0
1960/61	D	-	-	6.1	0.9	-	-	-	7.0
	A	2.9	10.1	26.6	4.9	3.3	2.4	-	50.2
	B	3.9	3.6	11.6	0.2	9.5	11.0	2.1	41.9
	C	-	-	-	-	-	0.9	-	0.9
.....	Total	6.8	13.7	44.3	6.0	12.8	14.3	2.1	100.0
1961/62	D	1.3	0.1	3.8	0.8	-	-	-	6.0
	A	4.0	17.7	26.5	7.8	-	-	1.7	57.7
	B	1.7	2.8	7.8	1.9	5.9	6.0	9.6	35.7
	C	-	0.1	-	-	-	0.4	0.1	0.6
.....	Total	7.0	20.7	38.1	10.5	5.9	6.4	11.4	100.0
1962/63	D	1.0	0.8	18.7	1.8	-	-	-	22.3
	A	5.7	12.4	20.8	4.4	-	0.1	1.9	45.3
	B	6.4	0.8	2.2	6.2	5.5	2.6	8.6	32.3
	C	-	-	-	-	0.1	-	-	0.1
.....	Total	13.1	14.0	41.7	12.4	5.6	2.7	10.5	100.0
1963/64	D	2.7	0.6	13.2	1.9	4.3	-	-	22.7
	A	9.3	27.6	17.3	3.6	4.5	-	0.1	62.4
	B	0.4	0.6	2.0	4.1	7.4	-	0.4	14.9
.....	Total	12.4	28.8	32.5	9.6	16.2	-	0.5	100.0
1964/65	D	18.3	4.7	3.8	9.1	2.3	-	0.1	38.3
	A	23.4	13.3	5.2	2.0	7.9	-	0.4	52.2
	B	0.	-	0.8	1.9	6.8	-	-	9.5
.....	Total	41.7	18.0	9.8	13.0	17.0	-	0.5	100.0

a/ Data referring to "D" are included with "A".

Catch per catcher day by season, species and division
(uncorrected for tonnage)

Season	Area / Series	II W	II E	III	IV	V	VI	I	TOTAL
Fin 1959/60	D a/	-	-	-	-	-	-	-	-
	A a/	1.30 o)1)	1.08 o)1)	1.60 o)1)	1.63 o)1)	1.41 1)			1.47
	B	1.04 1)	0.60 1)	0.94 o)1)	1.09 o)1)	1.18 o)1)	0.66 1)	0.92 1)	1.00
	C	-	-	-	-	1.24	0.54	0.03	0.49
.....	Total	1.16	0.98	1.27	1.56	1.21	0.62	0.80	1.24
Fin 1960/61	D	- o) 1)2)	- o)1)2)	o)1)2) 0.81 o)1)2)	o)1)2) 1.25 o)1)2)	- 1)	-	-	0.86
	A	1.04 1)2)	1.21 1)2)	1.39 o)1)2)	1.55 o)1)2)	1.01 o)1)2)	1.02 1)2)	- 1)2)	1.31
	B	0.92	0.77	1.16	0.47	1.05	0.91 1)2)	0.74	0.99
	C	-	-	-	-	-	0.82	-	0.82
.....	Total	0.97	1.10	1.25	1.49	1.04	0.92	0.74	1.14
Fin 1961/62	D	3) 0.31 o)2)3)	3) 0.00 o)2)3)	o)2)3) 0.86 o)2)3)	o)2)3) 0.28 o)2)3)	-	-	- 3)	0.65
	A	0.88 2)3)	0.91 2)3)	1.11 o)2)3)	1.17 o)2)3)	- o)2)3)	- 2)3)	0.31 2)3)	1.02
	B	0.37	0.54	0.88	0.59	0.62	0.62 2)	0.82	0.71
	C	-	0.64	-	-	-	0.10	0.11	0.23
.....	Total	0.65	0.85	1.04	0.99	0.62	0.59	0.74	0.88

a/ Data referring to "D" are included with "A"

o) Divisions fished in every year of the period 1959-1965
1) Divisions fished in both 1959/60 and 1960/61
2) Divisions fished in both 1960/61 and 1961/62
3) Divisions fished in both 1961/62 and 1962/63

Catch per catcher day by season, species and division
(uncorrected for tonnage)

Season	Area / Series	II W	II E	III	IV	V	VI	I	Total
Fin 1962/3	D	3)4) 0.10	3)4) 1.55	o)3)4) 0.79	o)3)4) 0.26	-	-	-	0 75
	A	o)3)4) 0.74	o)3)4) 1.12	o)3)4) 1.14	o)3)4) 0.79	-	0.26	3)4) 0.52	1·02
	B	3)4) 0.82	3)4) 0.12	o)3)4) 0.62	o)3)4) 0.60	o)3)4) 0.52	3) 0.57	3)4) 0.60	0·61
	C	-	-	-	-	0.35	-	-	0·35
.....	Total	0.73	1.08	0.96	0.62	0.51	0.56	0.58	0.83
Fin 1963/4	D	4)5) 1.08	4)5) 1.16	o)4)5) 0.40	o)4)5) 0.09	5) 0.28	-	-	0.45
	A	o)4)5) 0.68	o)4)5) 0.92	o)4)5) 0.97	o)4)5) 0.38	5) 0.38	-	4)5) 1.09	0.83
	B	4) 0.13	4) 0.67	o)4)5) 0.60	o)4)5) 0.34	o)4)5) 0.36	-	4) 0,14	0.39
.....	Total	0.74	0.92	0.72	0.31	0.35	-	0.36	0.68
Fin 1964/5	D	5) 0.28	5) 0.55	5) 0.55	5) 0.31	5) 0.11	-	2.20	0.34
	A	5) 0.45	5) 0.57	5) 0.85	5) 0.43	5) 0.33	-	0.69	0.50
	B	0.00	-	5) 0.34	5) 0.35	5) 0.21	-	-	0.25
	Total	0.38	0.56	0.69	0.34	0.25	-	0.89	0.42

o) Divisions fished in every year of the period 1959-1965
3) Divisions fished in both 1961-62 and 1962/63
4) Divisions fished in both 1962/63 and 1963/64
5) Divisions fished in both 1963/64 and 1964/65

Catch per catcher day by season, species and division
(uncorrected for tonnage)

Season	Area / Series	II W	II E	III	IV	V	VI	I	TOTAL
Sei 1959/60	D a/	-	-	-	-	-	-	-	-
	A a/	0.15 o) 1)	0.01 o) 1)	0.01 o)1)	0.09 o) 1)	0.41 1)	-	-	0.07
	B	0.28 1)	0.00 1)	0.05 o) 1)	0.37 o)1)	0.42 o) 1)	0.46 1)	0.36 1)	0.24
	C	-	-	-	-	0.50	0.10	0.00	0.12
.....	Total	0.22	0.01	0.03	0.13	0.42	0.36	0.31	0.15
Sei 1960/61	D	- o) 1) 2)	- o)1)2)	o) 1)2) 0.05 o)1) 2)	o)1)2) 0.14 o)1) 2)	- 1)	-	-	0.06
	A	0.40 1) 2)	0.05 1) 2)	0.02 o)1) 2)	0.06 o)1) 2)	0.34 o) 1) 2)	0.88 1) 2)	- 1) 2)	0.11
	B	0.74	0.06	0.04	0.08	0.13	0.57 1) 2)	0.20	0.28
	C	-	-	-	-	-	0.08	-	0.08
.....	Total	0.59	0.05	0.03	0.07	0.18	0.59	0.20	0.18
Sei 1961/62	D	3) 0.71	3) 0.00	o) 2) 3) 0.15	o) 2) 3) 0.31	-	-	-	0.29
	A	0.30 o) 2) 3)	0.04 o) 2) 3	0.03 o) 2) 3	0.23 o) 2) 3)	-	-	0.43 3)	0.09
	B	0.71 2) 3)	0.02 2) 3)	0.02 2) 3)	0.03 o) 2) 3)	0.23 o) 2) 3)	0.19 2) 3)	0.49 2) 3)	0.24
	C	-	0.00	-	-	-	0.22 2)	0.22	0.17
	Total	0.48	0.04	0.04	0.20	0.23	0.19	0.48	0.16

a/ Data referring to "D" are included with "A"

o) Divisions fished in every year of the period 1959-1965
1) Divisions fished in both 1959/60 and 1960/61
2) Divisions fished in both 1960/61 and 1961/62
3) Divisions fished in both 1961/62 and 1962/63

Catch per catcher day by season, species and division
(uncorrected for tonnage)

Season	Area / Series	IIW	II E	III	IV	V	VI	I	Total
Sei 1962/3	D	3)4) 0.55	3)4) 0.06	o)3)4) 0.29	o)3)4) 0.44	-	-	-	0.30
	A	o)3)4) 0.39	o)3)4) 0.08	o)3)4) 0.05	o)3)4) 0.12	-	0.05	3)4) 0.44	0.12
	B	3)4) 0.66	3)4) 0.02	o)3)4) 0.00	o)3)4) 0.24	o)3)4) 0.35	3) 0.58	3)4) 0.32	0.37
	C	-	-	-	-	0.00	-	-	0 00
.....	Total	0.54	0.07	0.16	0.23	0.34	0.56	0.34	0.24
Sei 1963/4	D	4)5) 0.76	4)5) 0.25	o)4)5) 0.48	o)4)5) 0.45	5) 0.45	-	-	0.50
	A	o)4)5) 0.62	o)4)5) 0.44	o)4)5) 0.19	o)4)5) 0.05	5) 0.51	-	4)5) 0.05	0.38
	B	4) 0.33	4) 0.00	o)4)5) 0.04	o)4)5) 0.08	o)4)5 0.63	-	4) 0.38	0.36
.....	Total	0.64	0.43	0.30	0.14	0.55	-	0.30	0.40
Sei 1964/5	D	5) 2.18	5) 0.22	5) 0.50	5) 0.85	5) 1.27	-	0.50	1.39
	A	5) 1.64	5) 0.73	5) 0.12	5) 0.40	5) 0.66	-	0.55	1.05
	B	0.00	-	5) 0.05	5) 0.18	5) 0.67	-	-	0.51
.....	Total	1.87	0.60	0.26	0.69	0.74	-	0.54	1.13

o) Divisions fished in every year of the period 1959-1965
3) Divisions fished in both 1961/62 and 1962/63
4) Divisions fished in both 1962/63 and 1963/64
5) Divisions fished in both 1963/64 and 1964/65

Catches of BLUE whales by season and division

Season	Area Series	II W	II E	III	IV	V	VI	I	TOTAL
1959/61	Da)	-	-	-	-	-	-	-	-
	Aa)	1	11	55	317	-	-	-	438
	B	26	20	176	32	384	10	11	659
	C	-	-	-	-	7	117	7	131
	Total	27	31	231	403	391	127	18	1228
1960/61	D	-	-	983	143	-	-	-	1126
	A	-	6	4	8	5	-	-	23
	B	17	105	165	-	85	206	5	583
	C	-	-	-	-	-	7	-	7
	Total	17	111	1152	151	90	213	5	1739
1961/62	D	-	-	326	34	-	-	-	360
	A	1	9	50	59	-	-	3	122
	B	67	111	101	4	74	29	212	598
	C	-	1	-	-	-	29	6	36
	Total	68	121	477	97	74	58	221	1116

Average catch per catcher day (uncorrected for tonnage) by species and season

Species and Season	Total catch total catcher days	Average of catch per catcher day per division, based on the divisions marked in the tables of catch per catcher day per division as						Average catcher tonnage
		0)	1)	2)	3)	4)	5)	
Fin whales								
1959/60	1.24	1.26	1.08					633
1960/61	1.14	1.10	1.01	1.01				642
1961/62	0.88	0.81		0.70	0.64			657
1962/63	0.83	0.73			0.68	0.69		703
1963/64	0.68	0.53				0.60	0.62	709
1964/65	0.42	0.45					0.43	715
Sei whales								
1959/60	0.15	0.16	0.21					633
1960/61	0.18	0.11	0.20	0.19				642
1961/62	0.16	0.15		0.21	0.24			657
1962/63	0.24	0.22			0.29	0.27		703
1963/64	0.40	0.33				0.32	0.36	709
1964/65	1.13	0.57					0.72	715

Index of catch per catcher day (corrected for tonnage) in successive seasons of the period 1959-1965 (1960/61 = 1.00)

Species and Season	Total catch Total corrected catcher days	Index based on average of catch per catcher day per division	
		Same division in all seasons (o))	Divisions the same by pairs of seasons, (1) to 5))
Fin whales			
1959/60	1.10	1.16	1.08
1960/61	1.00	1.00	1.00
1961/62	0.75	0.72	0.67
1962/63	0.66	0.60	0.66
1963/64	0.54	0.43	0.57
1964/65	0.33	0.37	0.39
Sei whales			
1959/60	0.85	1.45	1.05
1960/61	1.00	1.00	1.00
1961/62	0.87	1.28	1.05
1962/63	1.22	1.81	1.19
1963/64	2.02	2.62	1.44
1964/65	5.65	4.54	2.88

APPENDIX II

Report of the Committee of Four Scientists

(D.G. Chapman, K.R. Allen, J.A. Gulland, S.J. Holt)

of the International Whaling Commission

(Text of Document IWC/SM/13 and addenda)

1. This Committee was charged by the Commission at its Special Meeting, May 1965, with (a) reviewing the statistical analysis of the reports before the Committee relating to Item 3 of the Commission's agenda, (b) evaluating the effect on the stocks and catches of several schemes of regulation including those proposed by members of the Commission, (c) giving some measure of the limits of error involved in the Committee's analysis.

2. (a) Since the F.A.O. report IWC/SM/3 was prepared by a working group of three scientists two of whom were members of the Committee of Four and since it followed along the lines and methods of the studies in 1963 and 1964 by the Committee of Four it is readily apparent that we could not expect at this time and with the short time at our disposal, to add anything to the basic statistical analysis.

3. We wish to make it clear, however, that the Committee of Four has no hesitation in reaffirming that it is in unanimous agreement that the estimates of stock sizes and sustainable yields given in SM/3 and its addenda and supplement, are the best presently available. The events of 1963/64 and 1964/65 have served to confirm strongly the correctness of the assessments made in the Committee's reports as to fin whales as published in the 14th and 15th reports of the Commission. In 1963 it was not possible to make any assessment of the situation as to sei whales. It is obvious, as the F.A.O. report makes clear, that the present estimates of sei whale stocks and sustainable catches are much less firm that the same estimates for the fin whales. More specific comments on the limits of error will be given later.

4. (b) In evaluating the effect of the several schemes of regulations proposed it is necessary for us to pay attention to two additional factors

(1) the recruitments currently being added to the stocks which come from the larger parent stocks of some years ago.
(2) the probable division of the catch between the two major species remaining i.e. fin and sei whales.

5. Because the current recruitments are slightly larger than the sustainable yields of stocks of the present size the immediate effects of any regulation are slightly different from the long term effects. In evaluating the effects of quotas or other regulations we begin by assuming that the catches of fins and sei in future years will bear the same relationship to stock size as was the case in 1964/65.

6. Two kinds of regulatory schemes were proposed

(1) aimed at limiting the effort in 1965/66 to not more than 50 per cent of that in 1964/65.

(2) setting specific Blue Whale Unit quotas for one or more years.

Direct restriction of effort

7. A direct restriction of effort has some advantages over a catch quota because a level of effort of about one third of the 1964/65 level (i.e. with the present efficiency, about 5 expeditions, or 6,000 catcher days) will take around the sustainable yield, whatever the abundance of the stock. In contrast a specific catch quota may, if the stock is large, mean that less than the sustainable yield is taken, but if the stock is small, the same quota may be considerably larger than the sustainable yield.

8. However the catching power of individual expeditions and to a lesser extent of catchers, vary considerably, so that it is difficult to assess precisely the effects of restrictions of numbers of expeditions or catchers.

9. One proposal is that the number of expeditions should be halved. This should mean that the effort is halved, but this objective will not be achieved if the fishing power of each expedition is increased e.g. by increasing the numbers of catchers.

10. If the 1964/65 effort were to be exerted in 1965/66 the expected catch (supplement to IWC/SM 3) would be 7,000 fin whales and 15,000 sei whales, a total of 6,000 B.W.U. The expected catch with half the effort is therefore 3,000 B.W.U. and this proposal is considered from this point of view.

Effects of the Four Proposals

11. The proposals are :

(a) Quota of 4,500, 4,000 and 3,500 thousand B.W.U. for the next 3 years;
(b) Quota of 4,000, 3,000 and 2,000 thousand B.W.U. for the next 3 years;
(c) Effort for 1965/66 and the following years is reduced to 50% of the 1964/65 effort. As noted we have interpreted this as implying approximately a catch of 3,000 B.W.U.
(d) Quotas of 3,000 and 2,000 B.W.U. for the next two years. For consistency in the tables we have assumed a quota of 2,000 B.W.U. in the third year also.

12. The tables below are computed on the basis that the ratio of seis to fins in 1965/66 will be 2 to 1 and thereafter 1.5 to 1. This is the implication of the declining ratio of sei to fin stocks. Table 1 shows the expected catches and the required effort for the 3 years according to the several proposals.

Table 1a. Expected catches in 65/66, 66/67, 67/68

Proposed Regulation Quotas '000	1965/66		1966/67		1967/68	
	Fins	Seis	Fins	Seis	Fins	Seis
(a) 4.5, 4.0, 3.5 Quotas	5,400	10,800	5,300	8,000	4,600	7,000
(b) 4.0, 3.0, 2.0 Quotas	4,800	9,600	4,000	6,000	2,700	4,000
(c) 50% Effort	3,600	7,200	4,000	6,000	4,000	6,000
(d) 3.0, 2.0, 2.0 Quotas	3,600	7,200	2,700	4,000	2,700	4,000

Table 1b. Effort needed for catch indicated in table 1a (as percentage of 1964/5 effort).

	1965/6	1966/7	1967/8
(a)	75	67	58
(b)	67	50	33
(c)	50	50	50
(d)	50	33	33

Table 2 shows the state of the stocks and the relationship of actual catch to sustainable catch at the end of this 3 year period.

Table 2. Effect of the several proposals on Fin Whale Stock estimated to be 34,000 at the beginning of the 1965/66 season

(1) Proposals	(2) Size of stock at the beginning of the 1968/69 season (thousands)	(3) Sustainable catch after 1967/68 (thousands)	(4) Relationship of actual catch in 1967/68 to the sustainable catch as shown in column (3)
(a) 4,500, 4,000, 3,500 quotas	33.7	4.1	500 above
(b) 4,000, 3,000, 2,000 quotas	37.5	4.5	1,800 below
(c) 50% effort	37.4	4.5	500 below
(d) 3,000, 2,000, 2,000 quotas	40.0	4.8	2,100 below

Table 3. Effect of the several proposals on Sei Whale Stock estimated to be 44,000 at the beginning of the 1965/66 season

(1) Proposals	(2) Size of stock at the beginning of the 1968/69 season (thousands)	(3) Sustainable catch after 1967/68 (thousands)	(4) Relationship of actual catch in 1967/68 to the sustainable catch as shown in column (3)
(a) 4,500, 4,000, 3,500 quotas	27.2	2,000	5,000 above
(b) 4,000, 3,000, 2,000 quotas	33.4	2-3,000	1-2,000 above
(c) 50% effort	33.8	2-3,000	3-4,000 above
(d) 3,000, 2,000, 2,000 quotas	37.8	3,000	1,000 above

14. In computing table 3, we have taken into account the temporary bonus accruing during this period as recruitment comes from higher stocks of some years earlier. Thus the net change is smaller than would otherwise appear to be the case.

15. In summary the situation appears to be that three of these proposals bring the fin whale catch by 1967/68 to below the level of the sustainable yield but this is only at the expense of the sei whale stock. Only the second and fourth of these proposals would not necessitate further reduction after 1967/68 and even this only by some adjustment of the sei/fin ratio in the catch. If the first of these proposals were adopted a further reduction of the B.W.U. quota (from 3,500 to about 2,400) in 1968/69, would be necessary to bring the actual catch below the level of sustainable yields. Furthermore this first proposal leaves the stocks in 1968/69 in a very unfavourable position in regard to their potential for rebuilding back to the levels of maximum sustainable yield.

16. In these tables it has been assumed that the relative preferences for sei and fin whales which was shown in 1964/65 has been continued. This preference which led to a fishing mortality rate for sei whales about twice that for fin whales, was manifested mainly in the selection of the areas in which whaling was concentrated. It is possible that if, as a result of the regulatory system adopted, sei whales decreased in abundance relative fo fin whales, then this preference might diminish although it seems unlikely that it would be reversed leading to the selection of fin whales, as occurred in earlier years. If it did diminish then the quantities of fin whales taken would be rather greater and those of sei whales rather less than those used in our estimates, and the final stock levels in 1968/69 would be lower and higher respectively than those shown in our tables.

17. It is possible that some course of action could be followed which would lead to a reduction or stabilization of the fin whale catch at a level lower than would occur if the fleets continued to take either species only within the constraints set by the B.W.U. quota and the stock and the economic conditions. If such action were taken it would help to ensure the restoration of the resource of greater potential economic value, the fin whale, at the cost of increased risk to the less potentially valuable sei whale resource (20 to 1 in favour of fin whales) in terms of blue whale units. Further analysis would be necessary to determine what the effect would be of any such courses which might be suggested.

Limits of error in estimates

18. The estimates of stock size and sustainable yields and predictions of catches are based on consideration of several kinds of data of varying reliability, and take account of qualitative as well as quantitative evidence which gives a guide to the orders of magnitude and the likely limits of uncertainty.

19. Further detailed analyses of data as recommended in the Committee's earlier reports, could certainly narrow these limits further, but how much further we are unprepared to say at this time.

20. The estimates given have been, and inevitably will continue to be, made on evidence that is incomplete in several ways. An important factor in the predictions of catches and the state of the stocks under certain proposed regimes of regulations, is that the conditions of exploitation are not fully specified, and a range of assumptions has therefore to be made as to the way

the fleets will actually operate under a given regime; current examples are the specification of a B.W.U. quota without regulation of the catch of individual species, and the specification of the number of expeditions without indication of the number of catchers, the number of days they will work or the extent to which the more efficient expeditions will be those continuing to operate. If to this is added the uncertainty in making predictions for a particular season, of weather conditions and other causes of fluctuation, it will be appreciated that the Committee is not in a position to cite objectively determined values for the degree of uncertainty in its calculations.

21. Having said this we can only reiterate that we believe the estimates in the series of reports available to the Commission are the best available at this time. Further, the Committee remains confident that the estimates with respect to fin-whales are for all practical purposes correct.

22. Taking into account the actual effort and its distribution with respect to the various species the predictions made by the Committee as to fin-whale catches and total catches in terms of blue whale units have been correct to within 10%. Furthermore we believe the estimate of the sustainable catch of fin whales has the same degree of accuracy.

23. With respect to the sei whale the situation is, as we have said, rather different. We believe nevertheless that the estimates given in SM/3 are of the correct order of magnitude, and that it is appropriate to take action on the basis of the most likely values, rather than to delay regulatory action on grounds of uncertainty which inevitably implies, in effect acting as if these figures were under estimates. This would be unwise since it is possible that they are in fact over estimates. In any case it should be remembered that when the stock is below the level for maximum sustainable yield, the taking in a single season of a catch much higher than the sustainable yield will delay by several years the eventual recovery of the stock.

Explanation of Calculations for Tables 1a, 1b, 2 and 3

FIN WHALES

1965/66 1. Stock size at the beginning of this season 34 thousand (IWC/SM/3 Page 8)

2. Net recruitment 1966 6 thousand (12% of 1962 stock)

3. Catches 1965/66 (Sei/Fin ratio 2:1)
(a) 5.4 thousand
(b) 4.8 "
(c) 3.6 "
(d) 3.6 "

4. Stock size at the beginning of 1966/67 season under various proposals
(a) 34.6 thousand
(b) 35.2 "
(c) 36.4 "
(d) 36.4 "

1966/67 1. Stock size at the beginning of this season as in 4 above for for the four regimes

	2.	Net recruitment	1967	5 thousand (12% of 1963 stock)
	3.	Catches	1966/67	(a) 5.3 thousand (b) 4.0 " (c) 4.0 " (d) 2.7 "
		(Sei/Fin ratio 1.5:1)		
	4.	Stock size at the beginning of 1967/68 season under various proposals.		(a) 34.3 thousand (b) 36.2 " (c) 37.4 " (d) 38.7 "
1967/68	1.	Stock size at the beginning of this season as in 4 above for the four regimes.		
	2.	Net recruitment	1968	4 thousand (12% of 1964 stock)
	3.	Catches	1967/68	(a) 4.6 thousand (b) 2.7 " (c) 4.0 " (d) 2.7 "
	4.	Stock size at the beginning of the 1968/69 season under the various proposals.		(a) 33.7 thousand (b) 37.5 " (c) 37.4 " (d) 40.0 "

Comments on this table

(a) The stock sizes given in line 4 are obtained from the stock sizes of the previous year by adding the net recruitment and subtracting the catch.

(b) The net recruitments have been rounded to the nearest thousand since to carry these to hundreds would be to imply greater accuracy than the data merit. The stock size data also should be rounded to thousands but we have retained the additional figure to avoid cumulative errors in the successive steps and to make the calculations easier to follow. It should be emphasized that we do not wish to imply the stock sizes are accurate to the final figure. Quotas are given exactly and hence if catches are equal to quotas and are distributed between species in the indicated ratio catch figures are exact.

(c) The quotas referred to under (a) (b) and (d) are for the three seasons (a) 4.5, 4.0, 3.5 thousand
(b) 4.0, 3.0, 2.0 thousand
(d) 3.0, 2.0, 2.0 thousand

Regime (c) refers to 50% of the 1964/65 effort which for 1965/66 implies a catch of about 3,000 B.W.U. There might be some slight reduction of catches in 1966/67 and 1967/68 but for simplicity we have assumed a 3,000 B.W.U. catch throughout.

(d) A 2:1 sei/fin ratio implies that one blue whale unit would be made up of 2.4 sei whales and 1.2 fin whales, on the average. For a 1.5:1 sei fin ratio the corresponding equivalence would be 1 B.W.U. = 2.0 sei whales plus 1.3 fin whale on the average.

SEI WHALES

1965/66

1. Stock size at the beginning of this season (IWC/SM/3 and supplement) 44 thousand

2. Net recruitment 1966 3 thousand

3 Catches 1965/66
(a) 10.8 thousand
(b) 9.6 "
(c) 7.2 "
(d) 7.2 "

4. Stock size at the beginning of the 1966/67 season under various proposals
(a) 36.2 thousand
(b) 37.4 "
(c) 39.8 "
(d) 39.8 "

1966/67

1. as in 4 above

2. Net recruitment 3 thousand

3. Catches 1966/67
(a) 8.0 thousand
(b) 6.0 "
(c) 6.0 "
(d) 4.0 "

4. Stock sizes at the beginning of 1967/68
(a) 31.2 thousand
(b) 34.4 "
(c) 36.8 "
(d) 38.8 "

1967/68

1. as in 4 above

2. Net recruitment 3 thousand

3. Catches 1967/68
(a) 7.0 thousand
(b) 4.0 "
(c) 6.0 "
(d) 4.0

4. Stock sizes at the beginning of 1968/69
(a) 27.2 thousand
(b) 33.4 "
(c) 33.8 "
(d) 37.8 "

The tables above show the methods of calculation of Tables 1a and the second column of Tables 2 and 3. The estimated sustainable catches in column 3 of Table 2 for fin whales are calculated on the basis that the

annual net recruitment rate is 0.12. This is the difference between the recruitment rate and the annual mortality rate (r-M). For Table 3 (sei whales) the corresponding rate is estimated to be 0.08 at this time though it is again reiterated that this figure is subject to revision when more detailed studies have been completed.

Difference between regimes

The tables given in the report compare the results of different regimes in terms of catches taken, the stock sizes at the beginning of each season, and the sustainable yields from these stocks. Interest was also expressed as to how these regimes compared in terms of the time required for the stocks to recover to the optimum level giving the maximum sustainable yields The actual time taken will depend on what catches, less than the sustainable yield, are taken. Recovery is quickest if these catches are zero, and if that is the case during the first few years of recovery the difference in time between the most restrictive regime (d), and the least restrictive (a) is for fin whales one to two years. As the maximum sustainable yield is about 20 thousand fin whales, the difference in catch is 20 to 40 thousand whales (compared with a difference in catch in the next 3 seasons of just over 6 thousand whales). If the initial recovery is slower, because some small catches are taken, then the time differences will be correspondingly longer, and the difference in total catch also larger.

For sei whales, the difference in time for recovery to the optimum level between the most restrictive regime (d) and the least restrictive (a) will be about 4-5 years, (and longer if some whales are taken during the recovery period). As the maximum sustainable yield is about three thousand, this will cause a difference in catch of about 12-15 thousand sei whales.

The Committee is not competent to estimate the relative value of 6 thousand fin whales in the next three seasons, and 20-40 thousand whales in the future, though they would draw attention to the increasing world demand for food, especially animal protein, and the presumed associated rise in its relative price. The Committee would also draw attention to the fact that the total effort required to take the 6 thousand will be about the same as that required to take the 20-40 thousand.